or not. Upon sensing that the charge in the rechargeable power source 44 is below a predetermined level, the micro controller 46 signals the patient, via an audible alarm 320 and/or a vibrating alarm 322, that the rechargeable power source 44 should be recharged.

In FIG. 6 there is illustrated a block diagram of an implantable, rechargeable monitor and diagnostic system. The block diagram for the transmitter 12 is the same as the block diagram for the transmitter 12 shown in FIG. 1.

The block diagram for the receiver 14 contains the same power supply system, supply switching means and method for recharging the rechargeable power source 44 that already have been described in connection with the description of FIG. 1, but has been modified to incorporate the components required to assemble an implantable, rechargeable monitor and diagnostic system. These components are: 1) an amplifier/filter 406 used to amplify the desired biological signals and to filter out other undesirable signals; 2) an analog to digital converter 408 which is used to convert the biological signal into a digital value representative of frequency and amplitude of the biological signal; 3) a monitoring lead 410 containing electrodes 411–412 which are used to pick-up and carry the biological signals to the amplifier/filter 406.

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The mission of the monitor and diagnostic system shown in FIG. 6 is to monitor and record, in a non-volatile memory 414, specific biological signals and events occurring adjacent to the monitoring electrodes 411–412. Later, at a convenient time, these recordings can be telemetered to the transmitter 12 which will produce, via a graphic recorder 416, a hard copy of the biological signals for the physician's examination and eventual diagnosis. Any time biological signals occur, they are scrutinized by the micro controller 46 for specific morphology which would cause the event to be stored into the memory 27 for later examination by the physician. An example of a typical use, would be to record dysfunctional endocardiac signals which, when inspected by a trained physician, may reveal the origin of a cardiac dysfunction not detected by conventional means, such as a surface EKG.

From the foregoing description, it will be apparent that the RF coupled, implantable medical system 10 with the rechargeable back-up power supply/source 44 of the present invention has a number of advantages, some of which have been described above and others of which are inherent in the invention. Also it will be understood that modifications can be made to the RF coupled, implantable medical system including the rechargeable back-up power supply/source 44 described above without departing from the teachings of the present invention. Accordingly, the scope of the invention is only to be limited as necessitated by the accompanying claims.

We claim:

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1. An RF coupled implantable medical system comprising:

a transmitting unit;

a receiving unit including an implantable, electrically operated, medical device, RF energy receiving means, RF signal transmitting means and a rechargeable battery;

said transmitting unit including a power source, RF energy transmitting means, RF signal receiving means and first control means coupled to said RF energy transmitting means and to said RF signal receiving means for controlling the amount of RF energy transmitted to said receiving unit thereby to conserve on the amount of power obtained from said power source;

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second control means coupled to said RF energy receiving means, to said rechargeable battery, to said RF signal transmitting means and to said implantable medical device, for adjusting the charging current flowing into said rechargeable battery, as a function of (a) the charge level of said rechargeable battery, (b) selected charging rate, and (c) selected power supply for the implantable medical device.

2. The system of claim 1 wherein said receiving unit includes a titanium housing enclosing said RF energy receiving means, said RF signal transmitting means, said rechargeable battery and said second control means.

3. The system of claim 1 wherein said RF energy transmitting means of said transmitting unit is constructed to transmit energy at a frequency as low as 10 Hz and up to at least 20,000 Hz.

4. The system of claim 1 wherein said rechargeable battery has a temperature sensor which is mounted closely adjacent thereto and which is coupled via said RF signal transmitting means to said first control means of said transmitting unit whereby the level of transmitted RF energy can be reduced proportionally to the reduction in charging rate of the rechargeable battery in said receiving unit, in order to reduce the power consumption from said power source powering said transmitting unit.

5. The system of claim 1 wherein said RF energy transmitting means of said transmitting unit includes mode selection means for recharging said rechargeable battery at a "fast" (high energy) rate or at a "trickle" (low to medium energy) rate.

6. The system of claim 1 wherein said transmitting unit includes power source selection means for setting said receiving unit to obtain its operating power from (1) RF coupled energy ("RF only" mode), (2) said rechargeable battery ("battery only" mode) or (3) automatically switch to "RF only" upon detection of said RF energy field, or "battery only" when said RF energy field is not detected ("combination" mode).

7. The system of claim 6 wherein said receiving unit includes: (a) means for rectifying said RF energy into a relatively high D.C. voltage, (b) means for regulating said high D.C. voltage into a lower D.C. voltage, and (c) means for detecting the presence of said RF energy field,

said receiving unit, when set to operate in said "RF coupled energy" mode, is operable to supply regulated electrical energy to said implantable device so long as said transmitting unit is located proximate to said receiving unit and said receiving unit is sensing transmitted RF energy.

8. The system of claim 6 wherein said receiving unit, when said transmitting unit is set to operate in said "battery only" mode, is operable, periodically, to supply electrical energy to said implantable device from said rechargeable power supply for a period of at least 24 hours.

9. The system of claim 6 wherein said receiving unit, when set to operate in said "combination" mode, is operable to supply regulated D.C. electrical energy to said implantable device, so long as said transmitting unit is located proximate to said receiving unit, and, separately, to "trickle charge" said rechargeable battery to maintain same fully charged.

10. The system of claim 1 wherein said first control means of said transmitting unit includes means for controlling the level of RF energy transfer from the transmitting unit to the receiving unit relative to one or more of one or more of the following parameters: (a) the charge level of said rechargeable battery, (b) selected charging rate, and (c) the selected power supply for said receiving unit.

11. The system of claim 1 wherein said receiving unit comprises means for measuring the charge level of said rechargeable battery and, upon sensing a fully charged battery, automatically up-links a coded signal which commands said transmitting unit to "stop" transmitting RF energy.

12. The system of claim 1 wherein said transmitting unit includes a visual display coupled to said first control means.

13. The system of claim 1 wherein said transmitting unit includes a keyboard coupled to said first control means.

14. The system of claim 13 wherein said keyboard includes keys to start and stop recharging of said rechargeable battery within the implantable medical device.

15. The system of claim 1 wherein said implanted medical device is a tissue stimulator.

16. The system of claim 1 wherein said implanted medical device is a drug delivery system.

17. The system of claim 1 wherein said implanted medical device is a cardiac pacemaker system.

18. The system of claim 1 wherein said implanted medical device is a cardioverter/defibrillator.

19. The system of claim 1 wherein said transmitting unit includes a battery, whereby said transmitting unit is portable and not dependant upon an a.c. power source.

20. The system of claim 19 wherein said battery can be a rechargeable battery or a non-rechargeable battery.

21. The system of claim 1 wherein said RF energy transmitting means of said transmitting unit includes mode selection means for setting said transmitting unit to operate in one of the following modes: "RF only", "battery only" or a "combination of both".

22. The system of claim 21 wherein said RF energy transmitting means of said transmitting unit controls the amount of RF energy transmitted and,

(a) when said implanted receiving unit is set to operate in said "RF only" mode, said transmitted RF energy is automatically adjusted to the amount of RF energy required (i) to operate said implanted device and (ii) to maintain said rechargeable battery, which is powering said implanted device, in a fully charged state;

(b) when said implanted receiving unit is set to operate in said "battery only" mode, said transmitted RF energy is automatically adjusted to the amount of RF energy required (i) to operate said implanted device and (ii) to recharge quickly said rechargeable battery which is powering said implanted device; and,

(c) when said implanted receiving unit is set to operate in said "combination of both" mode, said receiving unit is set to switch automatically to either said "RF only" mode upon detecting said transmitted RF energy, or to said "battery only" mode upon detecting a loss of said transmitted RF energy.

23. An RF coupled implantable medical system comprising:

a transmitting unit;

a receiving unit including an implantable, electrically operated, medical device;

said transmitting unit including RF energy transmitting means, RF signal receiving means and first control means coupled to said RF energy transmitting means and to said RF signal receiving means for controlling the amount of RF energy transmitted to said receiving unit;

said receiving unit including RF energy receiving means, RF signal transmitting means, a rechargeable power supply coupled to said RF energy receiving means and

second control means for adjusting the charging current flowing into said rechargeable battery coupled to said rechargeable power supply means, to said RF energy receiving means, to said RF signal transmitting means and to said implanted medical device, and

mode selection means for setting said receiving unit to operate in one of the following modes: (1) "RF only", (2) "battery only" or (3) "combination of both".

24. The system of claim 23 wherein said receiving unit, when said transmitting unit is set to operate in said "RF only" mode, is operable to supply electrical energy to said implantable device, so long as said transmitting unit is located proximate to said receiving unit and said receiving unit is sensing transmitted RF energy.

25. The system of claim 23 wherein said receiving unit, when said transmitting unit is set to operate in said "battery only" mode, is operable, periodically, to supply electrical energy to said implantable device from said rechargeable power supply for a period of at least 7 days.

26. The system of claim 23 wherein said receiving unit, when said transmitting unit is set to operate in said "battery only" mode, is operable, periodically, to supply electrical energy to said implantable device from said rechargeable power supply for a period of at least 24 hours.

27. The system of claim 23 wherein said receiving unit, when said transmitting unit is set to operate in said "combination" mode, is operable to supply electrical energy to said implantable device through a rectifier directly to said implanted medical device, so long as said transmitting unit

is located proximate to said receiving unit, and, separately, to "trickle charge" said rechargeable power supply.]

28. An RF coupled implantable medical system comprising:

a transmitting unit;

a receiving unit including an implantable, electrically operated, medical device;

said transmitting unit including RF energy transmitting means, RF signal receiving means and first control means coupled to said RF energy transmitting means and to said RF signal receiving means for controlling the amount of RF energy transmitted to said receiving unit;

said receiving unit including RF energy receiving means, RF signal transmitting means, a rechargeable power supply coupled to said RF energy receiving means and second control means for adjusting the charging current flowing into said rechargeable battery coupled to said rechargeable power supply means, to said RF energy receiving means, to said RF signal transmitting means and to said implanted medical device; and,

said receiving unit comprising means for measuring the charge level of said rechargeable battery and, upon sensing a fully charged battery, automatically up-linking a coded signal which commands said transmitting unit to "stop" transmitting RF energy.

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29. An RF coupled implantable medical system comprising:

a transmitting unit;

a receiving unit including an implantable, electrically operated, medical device, RF energy receiving means, and a rechargeable battery; and

said transmitting unit including a power source and an RF energy transmitting means.

30. An RF coupled implantable medical system comprising:

a transmitting unit;

a receiving unit including an implantable, electrically operated, medical device, RF energy receiving means, and a rechargeable battery; and,

said transmitting unit including a power source and an RF energy transmitting means; and

control means coupled to said rechargeable battery, and to said implantable medical device, for adjusting the charging current flowing into said rechargeable battery.

31. An RF coupled implantable medical system comprising:

a transmitting unit;

a receiving unit including an implantable, electrically operated, medical device, RF energy receiving means, and a rechargeable battery;

said transmitting unit including a power source, RF energy transmitting means, and first control means coupled to said RF energy transmitting means for controlling the amount of RF energy transmitted to said receiving unit thereby to conserve on the amount of power obtained from said power source; and

second control means coupled to said rechargeable battery, and to said implantable medical device, for adjusting the charging current flowing into said rechargeable battery.